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May 1975

TECHNOLOGY UTILIZATION

ELECTRICAL AND ELECTRONIC DEVICES AND COMPONENTS

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

Compilations are now published in one of nine broad subject groups:

SP–5971: Electronics – Components and Circuitry
SP–5972: Electronics Systems
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SP–5974: Materials
SP–5975: Life Sciences
SP–5976: Mechanics
SP–5977: Machinery
SP–5978: Fabrication Technology
SP–5979: Mathematics and Information Sciences

When the subject matter of a particular Compilation is more narrowly defined, its title describes the subject matter more specifically. Successive Compilations in each broad category above are identified by an issue number in parentheses: e.g., the (03) in SP–5972(03).

This document is one in a series intended to furnish such technological information. Divided into three sections, this Compilation describes components and techniques that may be useful in the electronics industry. Section 1 contains articles on transducer technology including several applications. Section 2 is devoted to printed-circuit technology, and Section 3 contains descriptions of a variety of components, including solid-state devices.

Additional technical information on the articles in this Compilation can be requested by circling the appropriate number on the Reader Service Card included in this Compilation.

The latest patent information available at the final preparation of this Compilation is presented on the page following the last article in the text. For those innovations on which NASA has decided not to apply for a patent, a Patent Statement is not included. Potential users of items described herein should consult the cognizant organization for updated patent information at that time.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this Compilation.

Jeffrey T. Hamilton, *Director*
Technology Utilization Office
National Aeronautics and Space Administration

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Contents

Section 1. Transducers

STABLE EXCITATION SUPPLY FOR TRANSDUCERS

A feedback loop has been used to supply a stable ac voltage for the excitation of capacitance and inductance transducers when they are not incorporated into a null-balance readout system. Such transducers measure parameters including pressure, vacuum, liquid levels, displacements, fluid flows, and fluid densities.

Previous stabilization techniques included regulating the dc power supply to the oscillator or providing an external automatic gain control (AGC) to the oscillator, with incandescent lamps or field-effect transistors (FET's). These techniques required an excessive number of parts. Furthermore, AGC circuits using incandescent lamps were temperature sensitive and had a limited dynamic range; AGC circuitry employing FET's introduced distortion.

In this new circuit, an oscillator, a buffer, a rectifier, and an amplifier are connected in a feedback loop to regulate the voltage amplitude (see Figure 1). Distortion is kept low by changing the bias on the oscillator, instead of using AGC control devices. The amplitude can be selected over large ranges.

The circuit is shown in Figure 2; Q_1 and its associated circuitry form an oscillator in which the amplitude is controlled by the bias, and the frequency is determined by C_1 and L_1. Transistors Q_2 and Q_3 provide a buffer between the oscillator and the transducer. The network consisting of D_1, D_2, and C_2 rectifies and filters the oscillator output to provide a dc voltage, proportional to the oscillator amplitude. The output of the rectifier is compared to a reference voltage generated by D_3, and the difference voltage is amplified by operational amplifier Q_4. The output of Q_4 provides the appropriate bias to adjust the oscillator amplitude automatically, to bring the rectifier output very close to that of the reference. A breadboard version of the circuit was tested over the range –20° to +70° C, with both voltage and frequency being stabilized to 1 percent.

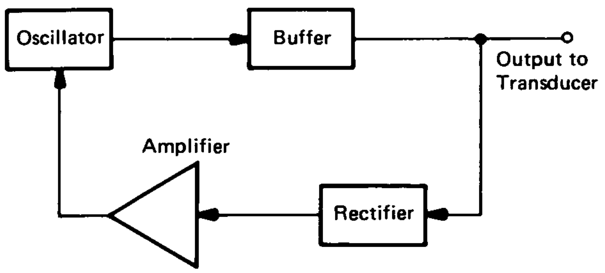


Figure 1. Block Diagram

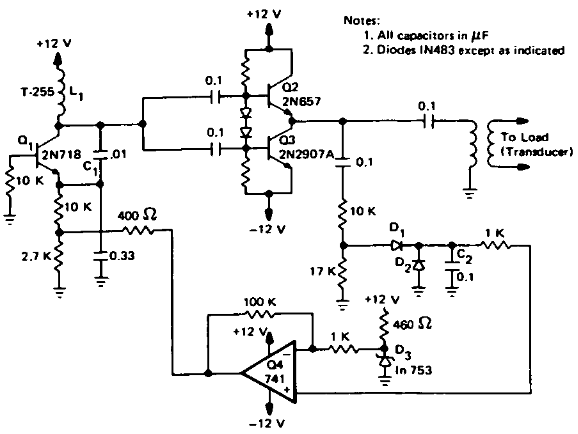


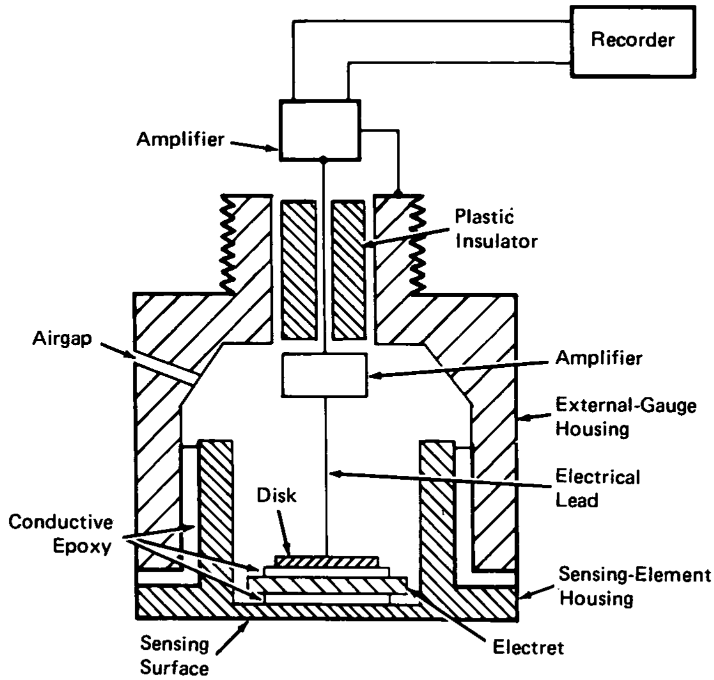
Figure 2. Circuit Schematic

Variations of the circuitry include eliminating the buffer, for applications requiring only light loads; adding a variable reference supply, to permit the output to be programed; and connecting the rectifier to the load, to eliminate loading errors caused by long cables.

Source: J. F. Hamlet
Marshall Space Flight Center
(MFS-21698)

Circle 1 on Reader Service Card.

ELECTRET POLYMER TRANSDUCER



Electret Transducer

Traditionally, impact transducers have been piezoelectric ceramics such as lead zirconate titanate ($PbTiZrO_3$) or quartz. Recently, however, a new class of piezoelectric materials has received considerable attention. Polymers, such as tetrafluoroethylene (TFE) and fluoronated ethylenepropylene resins (FEP), exhibit a limited piezoelectric effect in their natural states, and this effect is heightened considerably if the polymers are permanently polarized.

The permanently-polarized, or electret, state is produced by heating the polymer and placing it in an electric field, where it is allowed to cool. This material is much less expensive than ceramic piezoelectrics. Furthermore, small thin-film polymer transducers can be used with integrated-circuit amplifiers, to produce higher output voltages and frequency responses.

A complete transducer, using an electret polymer, is shown in the figure. The electret sensing element is metallized on both sides, and one side is bonded to a conductive housing with conductive epoxy. The other side is similarly bonded to a thin disk that is wired to a recorder. For a higher level of output signal, an amplifier may be added at either of the locations shown on the figure.

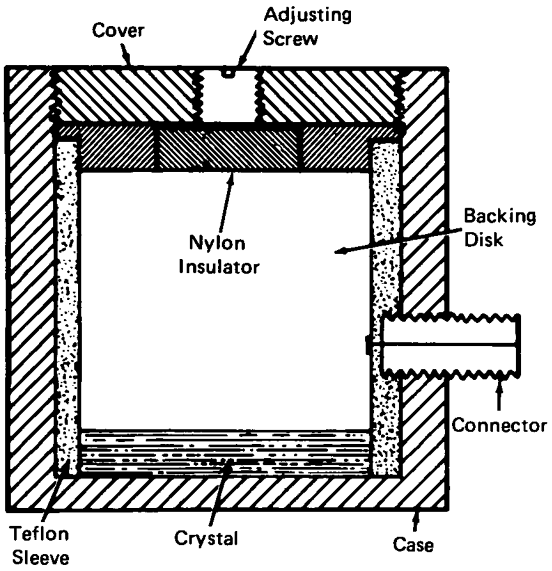
The front surface of the transducer is the sensing surface. The output voltage is generated between the wire to the recorder and the external housing of the transducer.

An electret transducer similar to the one shown here has been tested. With an impedance-converter amplifier, it produces an output signal of 220 millivolts, across a resistance of 1 megohm, and a capacitance of 100 picofarads, in response to an acoustic pulse. The more-expensive equivalent ceramic transducer produces approximately the same output signal.

Source: John R. Mastandrea and
Maurice V. Scherb of
McDonnell Douglas Corp.
under contract to
Langley Research Center
(LAR-11239)

Circle 2 on Reader Service Card.

A SONIC TRANSDUCER TO DETECT FLUID LEAKS



Typical Transducer Design

In order to detect leaks in or otherwise monitor moving fluid systems, elaborate chemical or spectrographic techniques usually are used. Time and expense could be saved by a simpler method for operating at cryogenic temperatures and, if necessary, in a vacuum, without disturbing the system being monitored.

A versatile ultrasonic detector for the measurement of fluid flow has been developed. The detector covers a wide frequency range and selectively detects spot frequencies or band frequencies for display and fingerprint analysis of gas flow or leakage.

This detector uses a set of contact transducers and band-pass filters to detect and analyze the sonic energy produced by the flow or leakage. A sensitive transducer is clamped in direct contact with the item to be monitored. The transducer converts the sonic and ultrasonic energy created by the fluid flow or leak into electrical energy, which is then amplified to be presented as an audible signal or to be displayed as a waveform. Tests show that the waveform differs for various conditions of flow and leakage, but at all frequencies tested the waveform is proportional to the flow rate when other conditions are constant. In most cases, the energy produced by flow systems is concentrated in a frequency range of 30 to 50 kHz. This leak-detection system, however, monitors the 1- to 100-kHz range to get better sensitivity and thus more information about the flow system.

A typical contact transducer used in this detector system is shown in the figure. A thin disk of lead zirconate titanate, backed by a thick metal disk, is isolated from the surrounding case by a Teflon cylinder. Electrical contacts are made through the backing disk and through the case bottom. Firm contact between the crystal, the backing disk, and the case bottom is maintained by compressing the entire assembly with adjusting screws. Sensitivity and resonant-frequency adjustments can be made by varying the degree of compression. A typical transducer has a minimum detectable output of about 5 μV and is part of a channel with an overall gain of about 85 dB.

This transducer system may be of use in leak detection, wear analysis, and flow measurements, in areas such as the automotive, petroleum, public utilities, and other industries.

The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $2.25)

Reference: NASA-CR-124618 (N72-12210), Study To Develop Improved Methods To Detect Leakage in Fluid Systems

Source: Issac Cimerman and John Janus of
Dynamatec Corp.
under contract to
Kennedy Space Center
(KSC-10704)

HEAT-FLUX TRANSDUCER USED TO MEASURE ENERGY CONVERSION

A new heat-flux transducer can be manufactured and calibrated for as little as one-tenth the cost of using conventional designs. In addition, it has several advantages over existing heat-flux transducers.

Conventional heat meters require thermal guarding, in order to reduce parasitic heat losses that interfere with measurements. Furthermore, calibration of conventional meters is complicated and costly, as it requires a thermal conductivity measurement. This new heat-flux transducer requires no complex thermal guard, and can be inexpensively calibrated during manufacture. It has a sensitivity of about 40 μV/W/cm^2 and is accurate to within 5 percent.

The new transducer is made by metallurgically bonding copper foil (for low-temperature use), or chromel P (for high-temperature use), to a layer of constantan (see Figure 1) 1 in. (0.25 cm) thick.

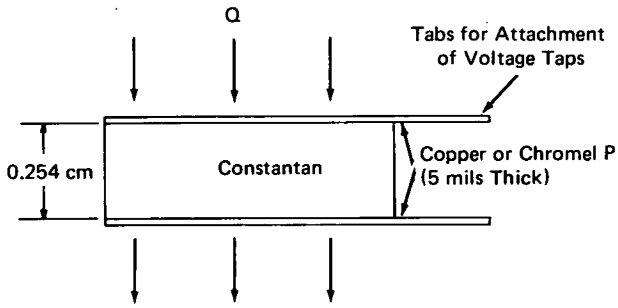


Figure 1a. Heat-Flux Transducer

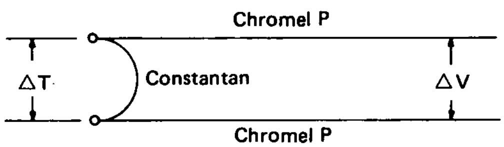


Figure 1b. Thermocouple Circuit

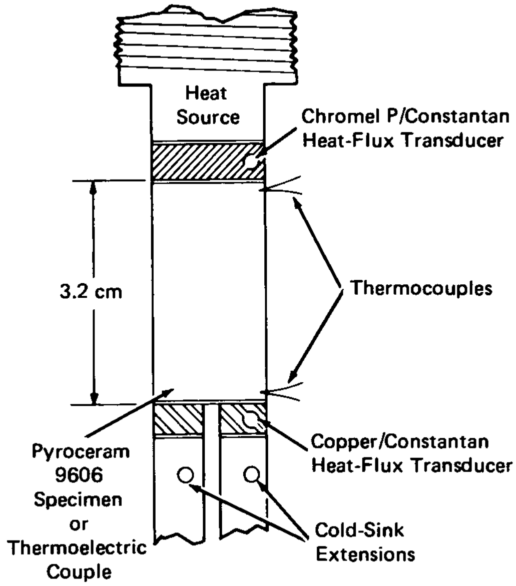


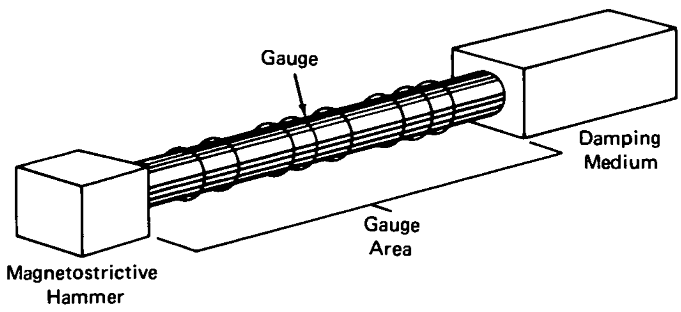
Figure 2. Calibration Standard or Thermoelectric Couple with Heat-Flux Transducers

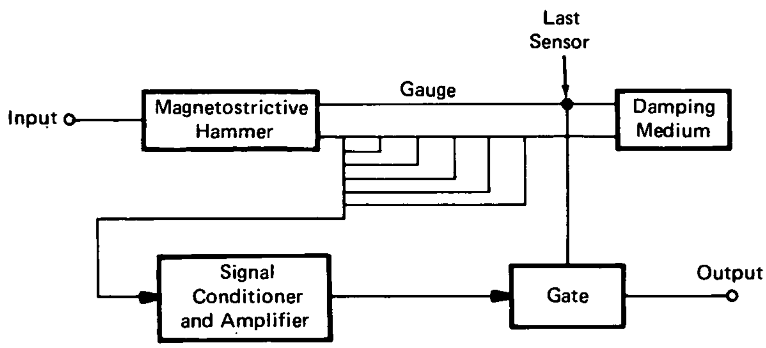
This transducer operates as a differential thermocouple, and the output voltage is approximately linear with respect to thermal flux, i.e., the temperature difference imposed between the thermocouple junctions formed at either side of the transducer. The transducer can be calibrated with a thermocouple calibration standard as shown in Figure 2.

Source: Phillip E. Eggers of
Battelle Memorial Institute
under contract to
Goddard Space Flight Center
(GSC-11057)

No further documentation is available.

TRANSDUCER MEMORY: A CONCEPT





Outline Drawing and Operating Schematic of Pulse-Coded Transducer

Magnetostrictive techniques have been used to convert mechanical-shock or sound waves into a series of electrical pulses. The pattern of the pulses may be varied by selectively spacing sensors in contact with a rod. This system would be particularly useful in the development of a digital transducer capable of generating a precoded signal in response to a mechanical event.

The transducer would be a rod as shown in the figure. If the rod is struck on one end, an elastic pulse travels down the rod, passing each of several circumferential sensors. Each sensor detects the expansion of the rod as the pulse passes by.

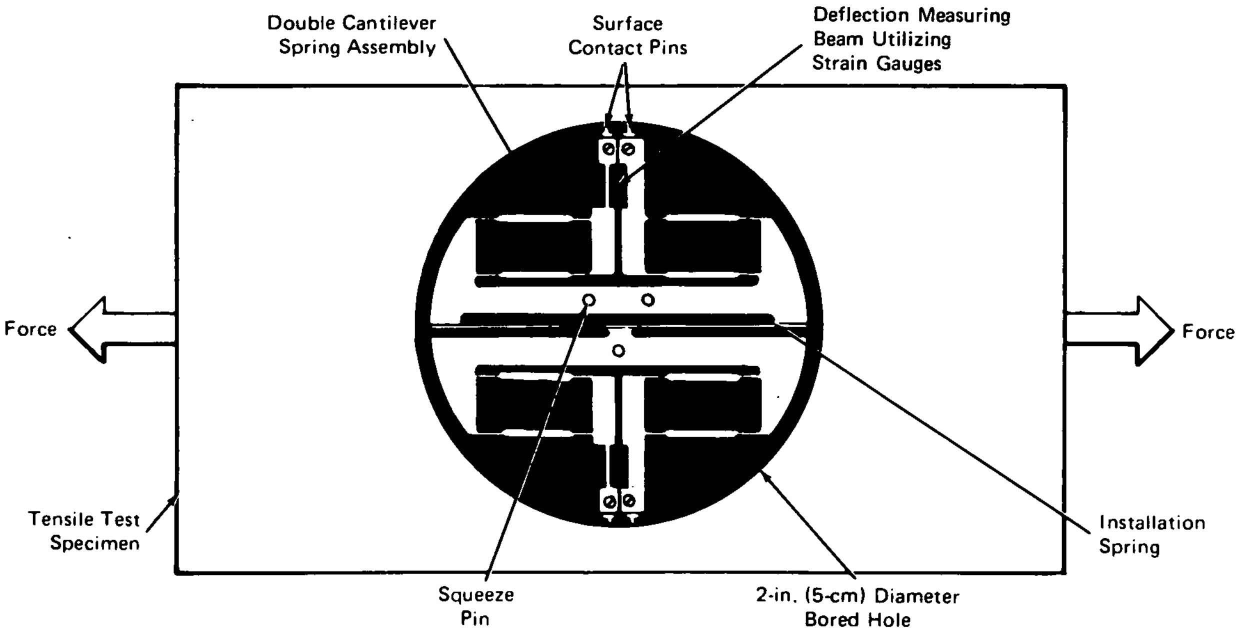
Rather than strike the rod mechanically, a magnetostrictive hammer supplies the pulse. When the pulse passes the last sensor, a gate circuit is triggered, which isolates the signal from any further input. The end of the rod is embedded in a damping medium that reduces the reverberation time.

One application of this system is to use the rods as a core memory. By spacing the sensors, a number of "words" could be stored on rods and recalled by activating the hammer.

Source: Frederich Bird of
Allied Research Associates, Inc.
under contract to
NASA Headquarters
(HQN-10410)

Circle 3 on Reader Service Card.

A SELF-SUPPORTING STRAIN TRANSDUCER



Strain Transducer

A strain transducer designed for measuring surface strains in the hole walls is used by the Langley Research Center Materials Division in low-cycle rate, high strain level fatigue studies of aircraft structural materials.

This transducer (see figure) features simplicity, since the self-contained mechanical measuring system is hand-mounted by simply compressing the installation spring and inserting the device into a hole of matching size. Diametrically opposed measuring heads are held in place by a compliant, motion-compensating spring loading system. It is self-alining as each contact pin maintains constant contact with the surface being measured.

The strain transducer is constructed from one piece, with the exception of the sharpened pins which contact the surface of the hole wall. A centrally located installation spring is compressed by finger pressure which allows the device to be inserted into the hole. Independent spring action allows each pin to maintain positive contact over a range of opposing contact pin spacing irregularities.

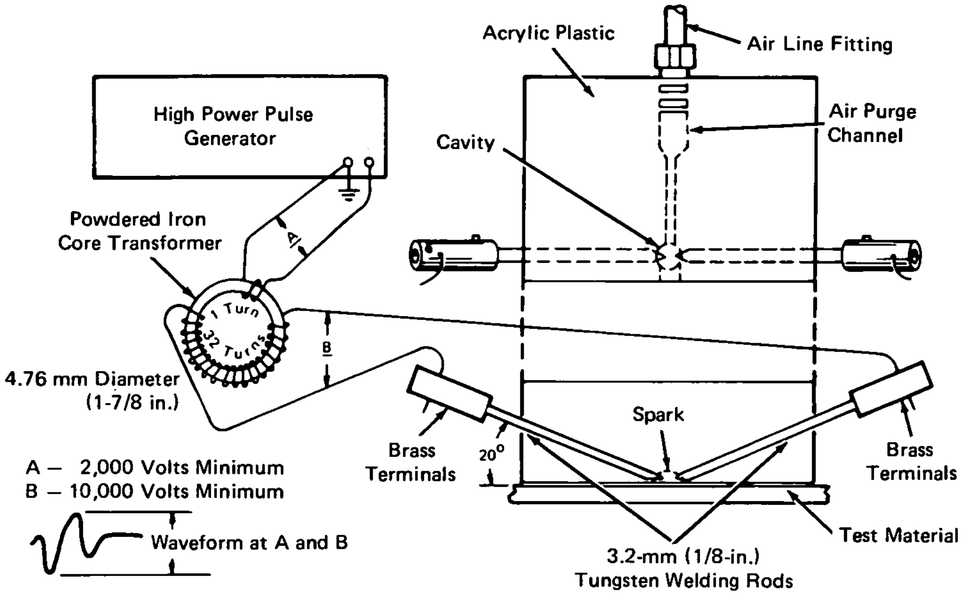
This device incorporates two independent measuring systems. Each system is equipped with a pair of contact pins with 0.1-inch (2.5-mm) spacing between pins. This spacing defines the gauge length on which measurements are made. When the surface between the pins of a pair is stretched or compressed during loading of the test specimen, the spring-loaded pins remain in intimate contact with the surface, and the separation between the pins changes to follow the specimen motion. One pin support arm of each pin pair is a flat cantilever spring arrangement which is designed to deflect in a predictable fashion due to the separation motion between the pairs of pins.

Conventional strain gauges are installed on this cantilever and are calibrated to yield an electrical signal which is proportional to the distance between pins. The strain level in this measuring beam is controlled by design to provide for measurements over an almost unlimited number of load cycles.

Source: Ira S. Hoffman
Langley Research Center
(LAR-11263)

No further documentation is available.

SPARK ULTRASONIC TRANSDUCER



Ultrasonic transducers used for nondestructive evaluation are usually of the crystal element type. A radio frequency pulse is applied to the crystal, causing it to vibrate. These ultrasonic vibrations are transmitted to the materials through liquid or paste couplant. In another method, force is applied to the crystal so that sufficiently intimate contact is made with the material to permit ultrasonic transmission. Because crystal transducers must be used with a couplant or coupling force, their application is limited to materials that are fairly smooth and not newly coated or porous. As a result of these disadvantages in using crystal type transducers, a spark ultrasonic transducer was developed which can induce ultrasonic pulses in materials without physical contact.

As shown in the illustration, a high power pulse generator feeds electrical pulses to the transducer through a step-up powdered core transformer. A 2000-volt minimum peak-to-peak pulse is required for the 1:32 transformer illustrated. (Another transformer operated successfully that had ten primary and fifty secondary turns and a slightly larger core. No significant difference in operating characteristics was noted.)

The transformer raises the pulse voltage to that required for sparking. A minimum of approximately 10,000 volts peak-to-peak is required. The output of the transformer is connected to two sharp-pointed 3.2-mm (1/8-inch) diameter tungsten welding rods that have brass sleeve-type terminals. The rods are supported by a nonconductive block of acrylic plastic. (None of the materials is considered critical; other materials may be used to produce the same results.)

The chief advantage of this spark ultrasonic transducer is its ability to induce pulses of ultrasonic energy in solids without actually contacting the surface. No couplant material is required which might contaminate the surface. Also, stress is not applied to the surface of materials, which permits testing of fragile samples. Because surface smoothness and contour problems are relaxed, pulses may be induced in light porous materials, which would otherwise absorb the couplant of other transducers. In addition, because strong ultrasonic pulses are generated in air, complex light materials such as foams, composites, and insulations can be tested. The final important advantage is that the pulses are generated at a point rather than over a broad area as with crystal transducers. This means greater resolution is possible at lower frequencies, which makes scanning applications more attractive.

Source: J. M. Hoop
Marshall Space Flight Center
(MFS-21233)

Circle 4 on Reader Service Card.

TRANSDUCER SYSTEM FOR ANGULAR MEASUREMENTS

A commercially available linear-displacement transducer has been used to measure the angular displacement of an antenna pedestal. The transducer system has several potential applications. It could be used for the numerical control of machine tools and to test other precision angular sensors such as synchronous transformers; it could also be used to position laser beams.

The sensor unit measures linear displacements of ±127 cm (±50 in.) to an accuracy of ±0.0013 cm (±0.0005 in.), and presents the readings on six-digit numerical displays. A circular disk is mounted on the antenna pedestal; the sensor is placed so that it is in contact with the disk. The diameter of the disk is 58.212 cm (22.918 in.) so that 0.0025 degrees of rotation will be indicated as 0.0013 cm on the display. A simple counter circuit, connected to the display, provides the interface to the digital readout.

This highly precise system has no backlash. It reads the rotation of the pedestal directly, thus eliminating the coupling and backlash errors that are common in conventional angular transducers (mounted coaxially with the pedestal via a flexible coupling). This system can be reset to zero easily, and the zero can be positioned at any desired point on the disk. Furthermore, by making the disk larger, more precision may be obtained.

Source: August K. Parr and
Emanuel Kramer of
IBM Corp.
under contract to
Goddard Space Flight Center
(GSC-11007)

No further documentation is available.

PRESSURE-SENSING TRANSDUCER MEASURES SHOCK WAVES

A pressure transducer has been designed to measure shock waves at high altitudes. The transducer has been used to measure pressure waves generated by grenades. In addition to the information gained on shock propagation, this system might be useful in determining temperatures and wind velocities in the upper atmosphere.

The transducer is a small pressure-sensing capacitive element. It is housed in a cylindrical container that is plugged into a solid-state amplifier. Each of the two outputs of the transducer has a different gain. When used with telemetry, each output may be broadcast over a separate channel, allowing a larger dynamic range than is possible with a single-channel system.

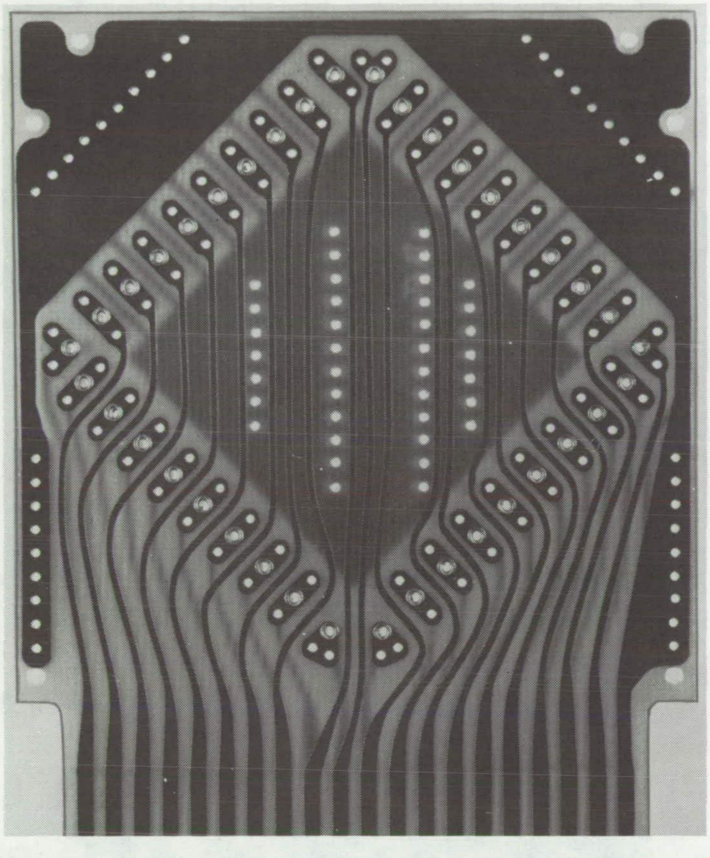
The transducer uses a capacitor microphone that is connected to a high-impedance field-effect-transistor preamplifier. The preamplifier output is amplified at the two gains, and it can be impedance matched to telemetry by an emitter follower with a voltage-limiting Zener diode in the input.

Source: Eugene S. Fennimore,
Leo Lavender, and
James W. Merrick of
Globe Universal Sciences Inc.
under contract to
Goddard Space Flight Center
(GSC-10964)

Circle 5 on Reader Service Card.

Section 2. Printed-Circuit Technology

CONNECTOR CARD FOR DIGITAL LOGIC SYSTEMS



Connector Card for Digital Logic Systems

A compact and inexpensive card-and-socket assembly has been used as a cable connector to join circuits such as power supplies and control apparatus to large scale integrated (LSI) circuits. With this connector card, the problem of fan-in and fan-out in connections between LSI and conventional circuits can be solved. Rewired or integrated circuits can be mounted on the connector card. A sufficient number of tie points and sufficient mounting space are available on the card to accommodate many integrated circuits or a single large integrated circuit. Such circuits might be used as in-line amplifiers, where the signal on a particular lead of the card connector is amplified before continuing through to the terminal of the card to complete the circuit through the socket of the connector.

This connector is best used with a ribbon cable; the terminal layout of the etched circuit is such that the leads of the cable require minimal bending after the cable is anchored to the card. The cable is anchored with a plastic clamp, fitted to the end of the card opposite the contacts. The terminals for the leads are laid out in a rectangular configuration (see figure).

Source: Edwin R. Adams of
Caltech/JPL
under contract to
NASA Pasadena Office
(NPO-11008)

Circle 6 on Reader Service Card.

PRINTED-CIRCUIT BOARD, TEST-POINT ADAPTER FOR CONFINED AREAS

This printed-circuit board, test-point adapter permits test-jack access to multiple-stacked printed-circuit boards. Several boards can be permanently displaced, thus making the components accessible for testing and calibration requirements. The usual dead space between PC board extenders is used for permanently-mounted test jacks.

Two commercially available printed-circuit board extenders are fastened together by machine screws; spacers are used to fix the exact distance between the boards. The applicable test points on the extenders are connected to four test-jack receptacles mounted in the spacer block. The test leads are connected to external measuring equipment. This principle can be extended by increasing both the number of printed-circuit board and the number of test-jack receptacles.

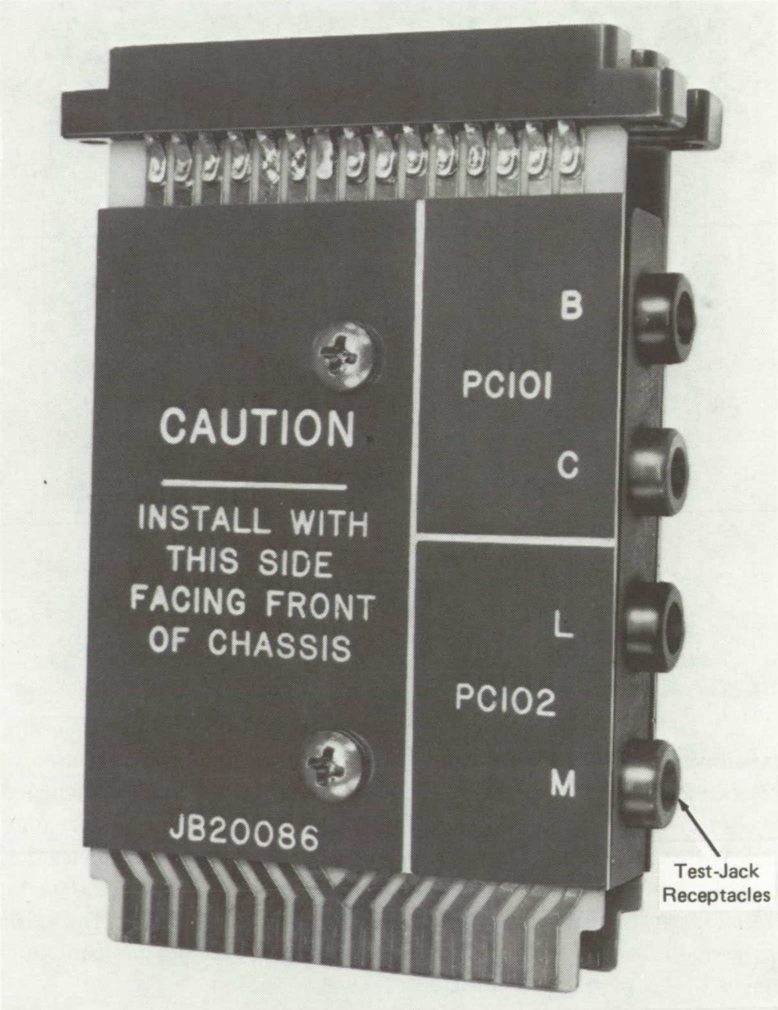


Figure 1. Printed-Circuit Attached Together With Spacers

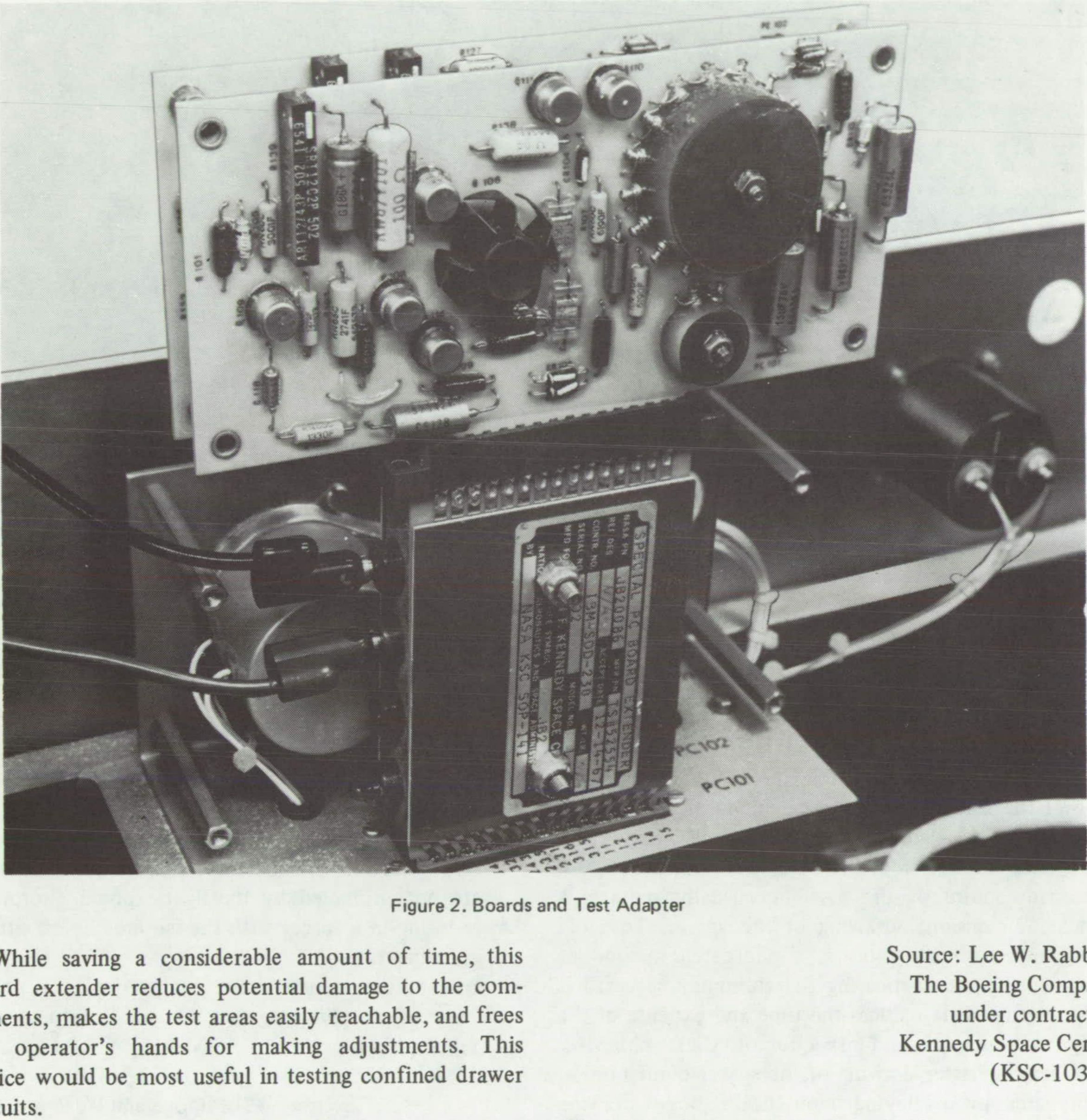


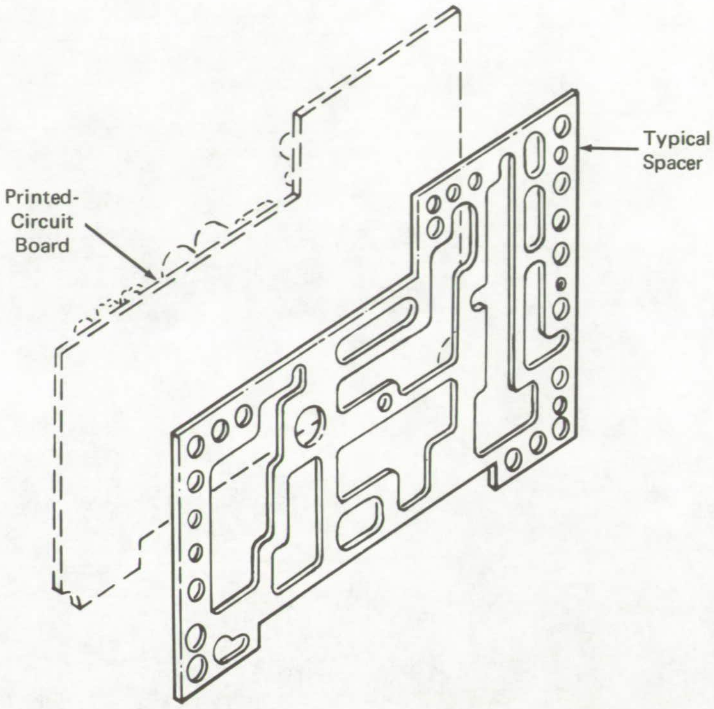
Figure 2. Boards and Test Adapter

While saving a considerable amount of time, this board extender reduces potential damage to the components, makes the test areas easily reachable, and frees the operator's hands for making adjustments. This device would be most useful in testing confined drawer circuits.

Source: Lee W. Rabb of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10338)

No further documentation is available.

IMPROVED INSULATING SPACERS FOR PRINTED-CIRCUIT BOARDS



Printed-Circuit Board and Spacer

When printed-circuit (PC) board assemblies with through-hole-mounted axial-lead components are assembled to a flat chassis, the PC boards must be spaced so that the solder joints have adequate clearance from the chassis (see figure). Aluminum spacers allow adequate heat transfer from the PC assembly to the chassis, but manufacture of the assembly usually requires a detailed dimensional drawing of the spacer. To avoid this time-consuming process, a photoetch method of documenting and fabricating flat aluminum spacers has been developed. It reduces the time and expense of the design, manufacture, and inspection of PC assemblies.

A scaled master drawing of the spacer configuration is prepared by overlaying it on the PC board drawing and taping or inking the overlay, to define the required configuration. A one-to-one photonegative of this scaled master then serves as a working tool for fabricating and inspecting the spacer.

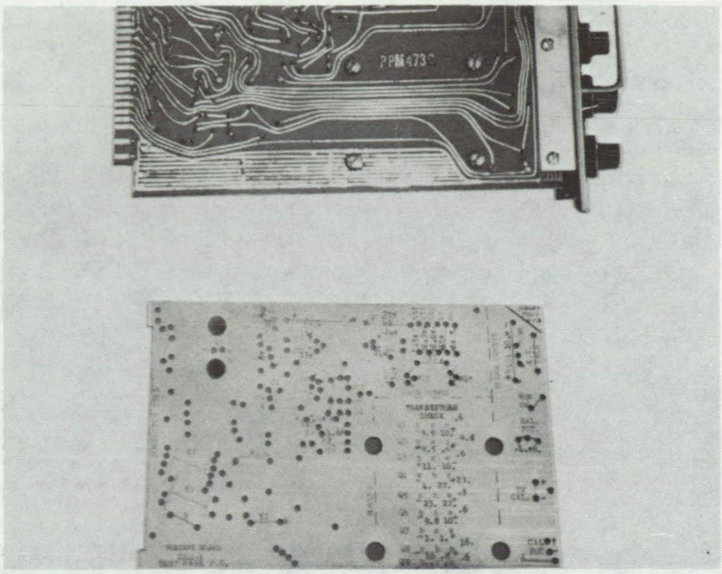
The manufacturing and inspecting procedures are as follows:

1. Apply photoresist to both sides of a flat aluminum sheet that has been trimmed to the approximate outside dimensions of the finished spacer.
2. Overlay the photonegative on both sides of the trimmed and photoresist-coated sheet, and expose it to high-intensity light.
3. Remove the photonegative from both sides after exposure, and spray the aluminum with a chemical-spray etchant. (The etchant attacks those areas that are not protected by the light-exposed photoresist, resulting in a spacer with the required holes, cutouts, and dimensions.)
4. Inspect the etched spacer by overlaying a positive copy of the photonegative that has been used in the fabrication process.

Source: W. L. Boone and W. E. Mertes of
IBM Corp.
under contract to
Marshall Space Flight Center
(MFS-22386)

Circle 7 on Reader Service Card.

SERVICE MASKS REDUCE TIME AND ERRORS IN CHECKING PRINTED-CIRCUIT BOARDS



Overlay Mask for Testing Printed-Circuit Boards

A new method reduces the time and error involved in electrically checking components mounted on printed-circuit boards for value faults and failures. Conventionally, circuit resistance and voltage have been checked by repeated references to separate schematics. Test points and values are identified from the circuit diagrams and are then located within the actual configurations on the circuit boards. Correlating information from the circuit diagrams, the assembly diagram (for location), and the wiring list is time consuming and subject to errors.

Overlay masks or templates of the same sizes and configurations as the circuit boards can solve these problems. The masks are perforated at the test points, and the test values are marked next to the perforations, as shown in the figure.

The masks are prefabricated for the specific circuit board to be checked. Normally, two masks are made for each circuit board, one for checking resistances and one for checking voltages. Thin sheets of cardboard, or other nonconducting material, are cut to the size and shape of the board. Components are positioned on the masks according to their exact locations on the board. Test points are located on the masks in the same manner, and the masks are perforated at each test point. Test values are calculated and marked on the masks adjacent to the pertinent test points.

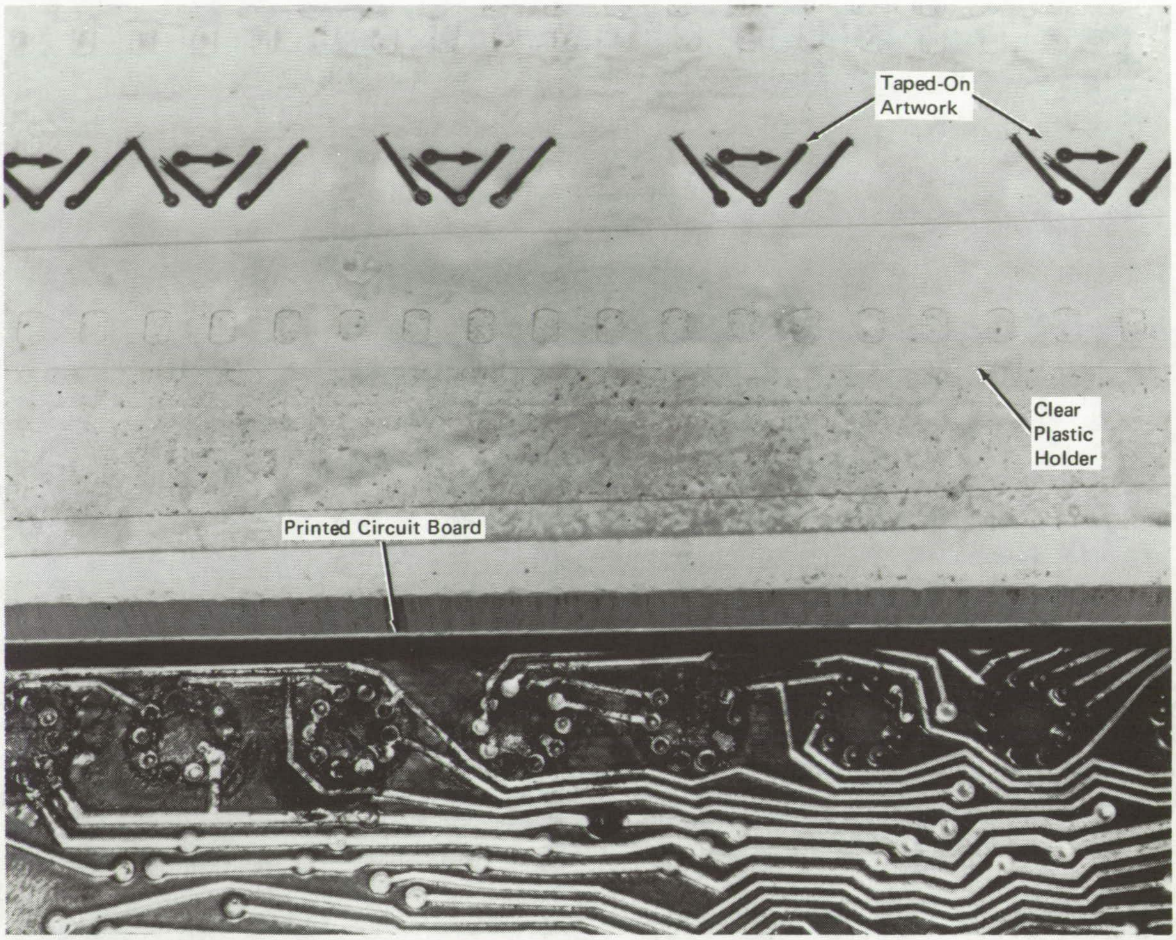
In use, each of the two masks is laid over the circuit board, and test probes are inserted through the appropriate perforations. The values measured by the test meters are readily compared to the values marked on the masks. If the readings indicate a problem, the measurements are transposed to a perforated schematic diagram, premarked with the correct measurements. Faults and failed components are quickly located. When the transposed measurements agree with the circuit measurements, the unit has been serviced.

Although masks are familiar production aids, this system is of particular interest because the use of a perforated schematic with the masks provides a complete checking system that can be used by relatively unskilled personnel.

Source: Anthony J. Kalilich
Lewis Research Center
(LEW-11743)

No further documentation is available.

SHORTCUT FOR REPAIRING DAMAGED CIRCUIT BOARDS



Clear Plastic Mask as Used to Etch Printed Circuits

A shortcut technique permits in-house repair of circuit boards that have been damaged during the removal of components. It is a timesaving and money-saving alternative to the replacement of entire circuit boards, which can be extremely expensive for specially designed modules.

Replacement sections of land areas are produced by making a font disk of clear plastic. The appropriate patterns are placed on the plastic and then are used to expose a photoresist to ultraviolet light. The replacement sections are etched out chemically and subsequently are attached to existing circuitry by sweat soldering.

The illustration shows a circuit board section after component removal. It also shows typical taped-on artwork, on a clear plastic holder used to produce chem-milled replacement sections.

Source: G. E. Lotgering of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-19283)

No further documentation is available.

NONFLAMMABLE POTTING, ENCAPSULATING AND/OR CONFORMAL COATING COMPOUND

A polymer material formed from dimethylpolysiloxane, ammonium phosphate, and ground glass, provides a nonflammable potting, encapsulating, or conformal coating compound. It is nonflammable in an air environment and self-extinguishing in an atmosphere of 60 percent oxygen and 40 percent nitrogen. The table gives the formulation of the material.

Ingredient	Percentage by Weight
Dimethylpolysiloxane Resin	42.56%
Ammonium Phosphate, Monobasic	31.91%
Glass, 325 Mesh	21.28%
Dimethylpolysiloxane Curing Agent	4.25%

The ammonium phosphate appears to inhibit or retard combustion by interfering with the free radical chain reactions. In addition, gas emitted by the hot ammonium phosphate causes intumescence of the dimethylpolysiloxane and creates an insulating gaseous layer. The glass, which melts at low temperatures, reduces the rate of heat transfer within the material.

This material may have applications for reducing industrial fire hazards. Also, results of preliminary dielectric property measurements indicate a potential use in electrical component encapsulation.

This material should interest the aircraft industry, machinery manufacturers, the automotive industry, and manufacturers of encapsulating, potting, and conformal coating polymers.

Source: H. F. Kline and Fredrick Dawn
Johnson Space Center
(MSC-13499)

Circle 8 on Reader Service Card.

REMOVING SILVER SULFIDE FROM SILVER-PLATED ELECTRICAL CONNECTORS

Silver-plated terminals tarnish in an atmosphere with a high sulfur content, resulting in poor electrical contact. Conventional cleaning agents, such as ketones, alcohols, or ultrasonic treatment will not remove the tarnish.

However, silver sulfide tarnish may be removed by the following process:

a. Degrease the tarnished part with any good chlorinated solvent (e.g., trichloroethylene).
b. Immerse the terminals in an aqueous solution of 45 g NaCN (sodium cyanide) per liter of water (6 ounces to one gallon), for 15 to 20 seconds.
c. Rinse at least three times in cold demineralized water.
d. Dry the rinsed terminal thoroughly with an oil-free airblast.

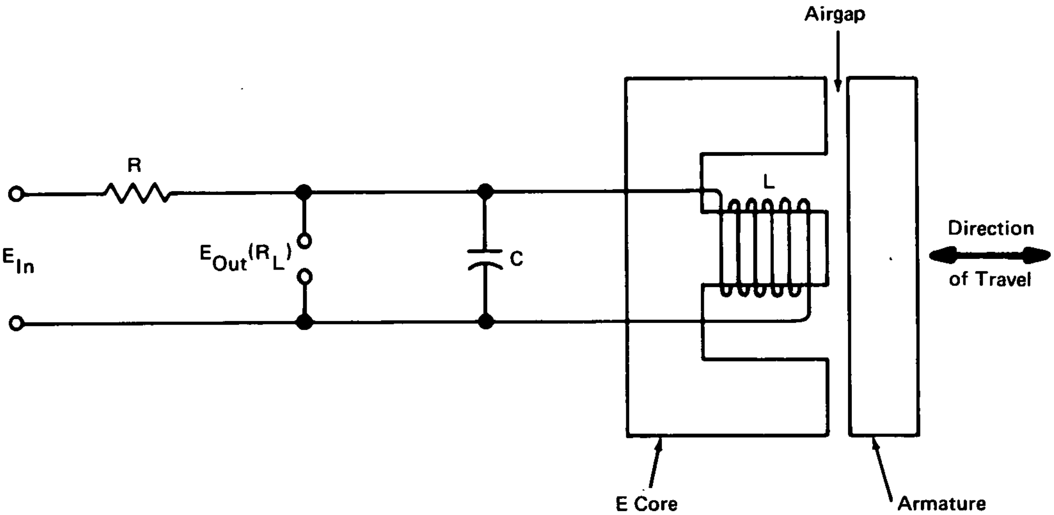
This method should be used only to clean terminal boards and the attached terminals, not final assemblies. In complex assemblies, the solution may become trapped and corrode the system. As a safety precaution, it should be remembered that cyanide solutions are highly toxic and should be used only by qualified people, in a well-ventilated area.

Source: Harley Harman of
The Boeing Company
under contract to
Kennedy Space Center
(KSC-10263)

No further documentation is available.

Section 3. Miscellaneous Components

RESONANT-INDUCTOR POSITION INDICATOR



A resonant RCL circuit has been combined with a variable inductance to produce a mechanical-position indicator. This indicator has no electromechanical contacts, is not affected by temperature variations, and is compatible with most commonly used logic circuits. It can provide a reliable indication of small mechanical movements and is especially useful when measurements must be taken over a broad temperature range.

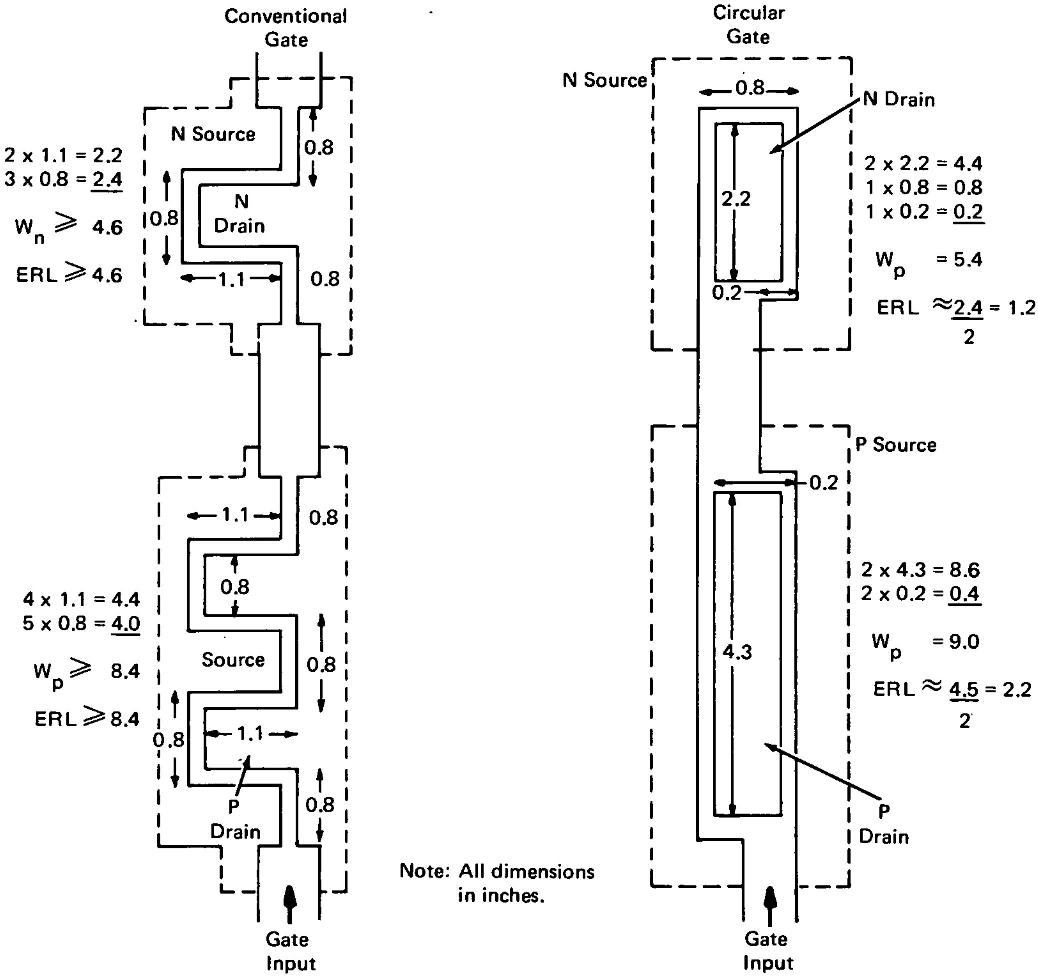
The indicator is shown in the figure. It consists of a variable inductor (L) in parallel with a capacitor (C) and a load resistor (R_L). The parallel RCL circuit is in series with a dropping resistor (R). The conductance of the inductor and the capacitor is a function of the excitation frequency. For a given excitation frequency and capacitor, an inductor can be selected so that the conductance of the capacitor and the inductor is zero (in resonance).

This resonant circuit is equivalent to a circuit containing a dropping resistor in series with a load resistor across the input power supply. If the inductance is changed by introducing a small variable airgap into the coil core, the circuit is no longer resonant; the conductance of the capacitor and the parallel conductor increases dramatically. The load resistance (R_L) is essentially shorted out, and practically all of the voltage drop is across R. When the armature is connected to a moving mechanism, the resonant-inductor circuit becomes a position indicator which produces a large change in output voltage, in response to a small mechanical motion.

Source: A. W. Nease and
W. S. Robins of
Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-24466)

Circle 9 on Reader Service Card.

IMPROVED GATE STRUCTURE FOR MOS TRANSISTORS



Comparison of Conventional and Circular Inverters

The use of a polysilicon gate structure has been of recent interest in complementary-symmetry metal-oxide semiconductor (CMOS) technology. One drawback of this material is the reduction of speed in the gate structure. This is due to the inherent resistance of the polysilicon and the capacitance of the gate structure, which create a distributed RC-delay line. This combination delays the actual transistor action, until the signal has trickled through the gate structure. A circular-gate structure shortens this delay by 10 to 15 percent.

In the figure, a conventional gate is compared with a circular gate. The effective resistive length (ERL) of the conventional gate is four times greater than that of the circular structure. In addition, the drive capability of the circular-gate transistor is greater. This can be seen in the comparison of the W_p and W_n numbers; the higher numbers represent higher fanout.

Source: P. W. Ramondetta of
RCA Corp.
under contract to
Marshall Space Flight Center
(MFS-22616)

Circle 10 on Reader Service Card.

THERMOCOUPLE TAPE

A preformed, low cost, thin film thermocouple in the form of an adhesive tape has been conceived and a prototype fabricated. The sketch depicts such a disposable thin film thermocouple tape with preformed junctions. As shown in Figures 1 and 3, a thin layer of metal "A" is deposited along one edge of a plastic tape, and a thin layer of a dissimilar metal "B" is deposited along the other edge of the tape and overlaps layer "A" to form a thermocouple junction area along the center portion of the tape. Figure 2 illustrates a thermocouple formed from a length of tape by severing the layer of metal "B" at the middle of the tape length and removing a strip of the center overlap to form an aperture. This establishes a measuring junction at one end of the tape length and a reference junction at the other end. The low mass of the thin film thermocouple junction area contributes a fast response time. The two portions of the severed metal "B" layer may serve as connecting leads to the measuring apparatus. Figure 3 illustrates the adhesive layer applied to the bottom of the tape and a protective (optional) cover applied to the top.

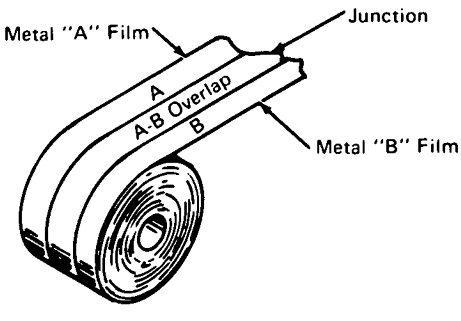


Figure 1. Roll of Thermocouple Tape

The self-adhering thermocouple tape can be manufactured in a variety of materials, sizes, and configurations. For example, the thermocouple adhesive tape could be made in roll form and dispensed in the same manner as commercial plastic tapes. By dispensing the appropriate length of thermocouple tape, pressing it to the surface to be monitored (including lead-in areas if desirable), and tearing away the appropriate length of preformed junction area; a complete custom fitted thermocouple could be installed and attached to a measuring instrument without the aid of soldering or welding equipment or other additional attaching materials. The junction areas could be made as large or as small as desirable; the only tools needed would be a knife or a pair of scissors.

The cost of the thin film thermocouple tape should be low, compared to commercial wire thermocouple materials, due to the low mass of metal required for

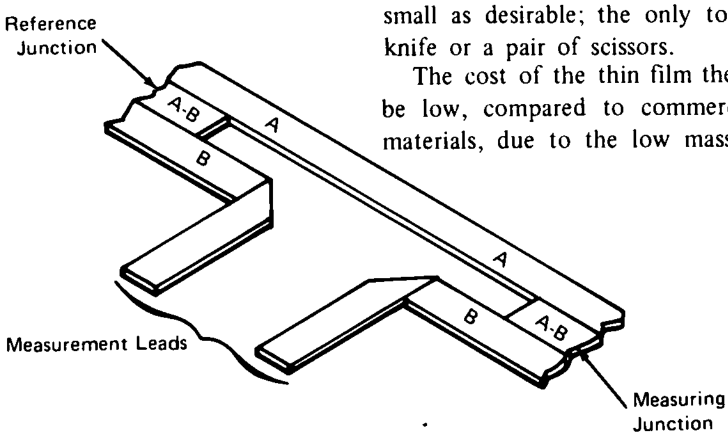


Figure 2. Complete Preformed Thermocouple

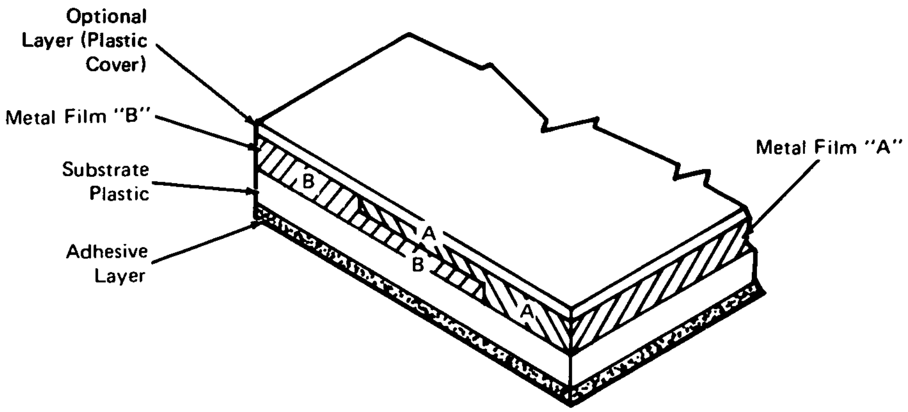


Figure 3. Cross Section

the thin films, particularly in the case of noble metal thermocouples. The design of the thermocouple tape is readily adaptable to automated production.

A prototype thin film copper-constantan thermocouple tape was successfully fabricated using sputtering techniques for applying the metal films. Films of copper and constantan nominally 6000 angstroms thick were deposited on an 0.051-mm (0.002-inch) thick polyimide plastic film. The useful temperature range for the polyimide film selected (estimated to be the minimal useful range for the tape thermocouple) was 4 K to 673 K. Initial evaluation of this tape thermocouple showed good agreement with a standard wire thermocouple at 298 K with an ice bath reference temperature.

Thermocouple	EMF (Ice Bath Ref)	T(K)
Thin film tape (copper-constantan)	+0.87 mV	296
Commercial wire (copper-constantan)	+0.96 mV	298

The –2 K discrepancy observed for the tape thermocouple is believed to be attributable to the short conduction path length (16.5 cm or 6.5 in) between the reference and measuring junctions of the prototype.

This thermocouple, in the form of a tape, may be easily and quickly sized, formed, and applied. It's use could be extended to higher temperatures by proper selection of substrate, adhesive, and protective cover materials.

The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $2.25)
Reference: N71-31123, Thermocouple Tape Patent Application (SN 104,885)

Source: Ralph D. Thomas and
George A. Mazaris, Jr.
Lewis Research Center
(LEW-11072)

INSULATED ECG ELECTRODES

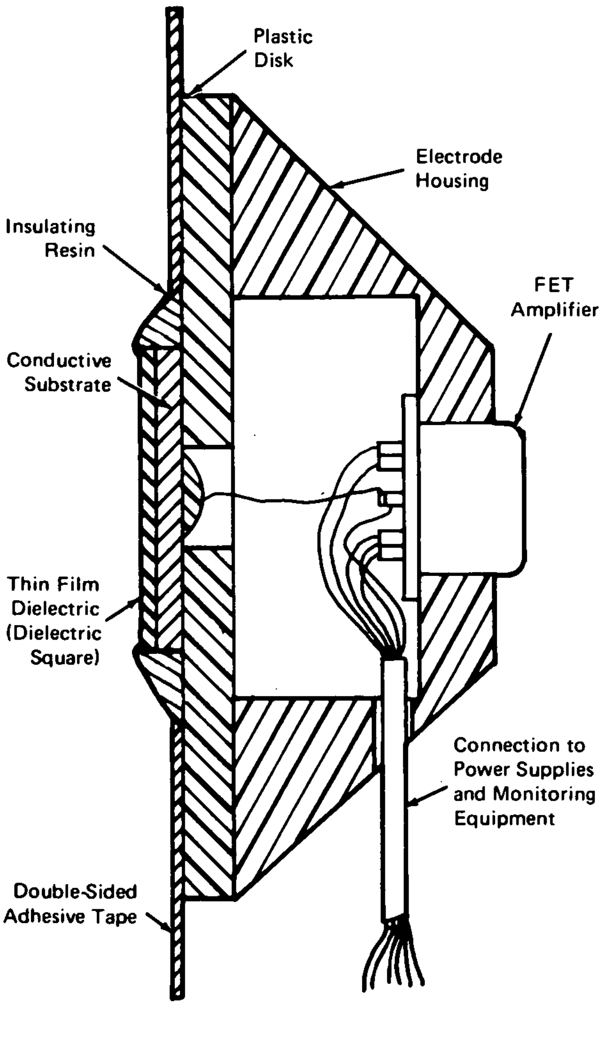
A silver-silver chloride electrode is commonly used with present electrocardiogram (ECG) systems. It is attached to human skin with an electrolyte paste which provides a low resistance path from the skin to the electrode. This method imposes several disadvantages. When the paste is left on over an extended period, it will dry and increase the skin-to-electrode resistance. Bacteria or fungi may then grow under the electrode and cause skin irritation. In addition, the shifting potential at the electrode-skin interface causes a baseline drift in the recording and distorts the readings. Readings are also distorted when the subject moves.

An insulated, capacitively coupled electrode does not require electrolyte paste for attachment, thereby eliminating all of the above-mentioned problems.

Compatibility of the electrode with existing ECG systems is provided by a high-performance, FET (field-effect transistor) electrode amplifier connected in a unity-gain configuration to function as an impedance transformer. Thus, the high source-impedance of the capacitively coupled electrode is made compatible with systems using paste-type electrolytes which have a low impedance.

The electrode (see figure) is formed by depositing a thin film dielectric onto a conductive substrate by radio-frequency sputtering, which mechanically bonds the dielectric material to the substrate. A high-performance, FET electrode amplifier is electrically connected to the dielectric square and is mounted in a plastic electrode housing. The dielectric is fastened to a plastic disk with an insulating resin, which precludes possible contact between the skin and the substrate, thus avoiding any skin-to-substrate shorts. The dielectric square is electrically connected to the amplifier by a wire conductor. Wires which extend through an opening in the side of the housing provide electrical connections to the power supplies and monitoring equipment.

The electrode is applied to the skin with double-sided adhesive tape. The dielectric material is thus held closely against the skin surface to produce a capacitor configuration in which the skin acts as one plate of the capacitor and the substrate as the other. Because of its capacitive action, the electrode inherently blocks dc drift at the electrode-skin interface.



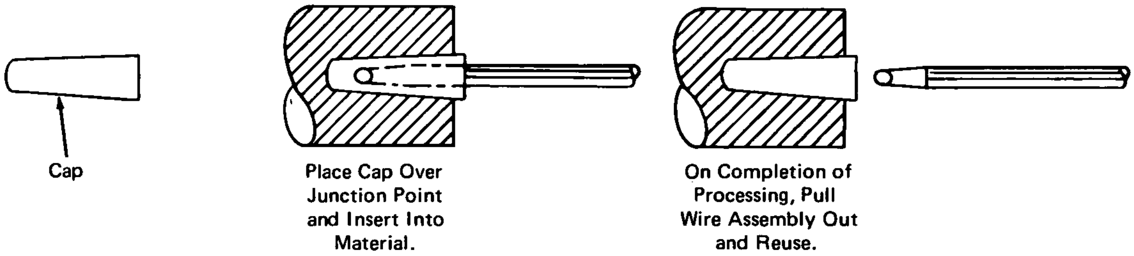
Insulated, Capacitively Coupled Electrode

Other features of the electrode include a wide range of nontoxic material that may be employed for the dielectric because of the sputtering technique used. Also, the electrode size is reduced because there is no need for external compensating networks with the FET operational amplifier.

The following documentation may be obtained from:
National Technical Information Service
Springfield, Virginia 22151
Single document price $3.00
(or microfiche $2.25)
Reference: NASA CR-115530 (N72-22096), The Development of Insulated Electrocardiogram Electrodes

Source: W. M. Portnoy and R. M. David of
Texas Technological University
under contract to
Johnson Space Center
(MSC-14339)

TECHNIQUE FOR RECLAIMING THERMOCOUPLES



Capping Thermocouple Wires

By a simple additional step during installation, thermocouples may be removed from potting compounds without damage. If, as in the case for thermal or cryogenic processing, large amounts of thermocouple wires are used for testing and design, this procedure can add up to a significant cost savings.

Thermocouple-wire assemblies are most often damaged because the junction point is embedded in adhesive, resin, or potting compounds. After the potting compound solidifies, the wire cannot be removed without damage to the junction point. However, if the junction point is capped with a piece of halohydrocarbon film (commercially available), the wire can be removed easily. The film allows the wire to be secured, but keeps it from being frozen in the potting medium or adhesive. The procedure is illustrated in the figure.

Source: M. Nagaoka of
Rockwell International Corp.
under contract to
Johnson Space Center
(MSC-15612)

No further documentation is available.

SOLID-STATE CURRENT TRANSFORMER

This innovative solid-state current transformer is a simple electronic network that employs a very low input impedance to achieve a linear transfer characteristic over a wide bandwidth. These characteristics are similar to those of a bipolar transistor in a common-base configuration, except that a common-base transistor stage has a significant input impedance and, therefore, is linear only when it is driven by a current source.

This solid-state circuit functions like a unity-turns-ratio (1:1) current transformer; but unlike its mutually-coupled inductive counterpart, it does so unilaterally, through an essentially 1-to-infinity input-to-output impedance level. This provides for excellent input-to-output isolation.

The circuit is shown in Figure 1. Transistors Q_1 and Q_3 act as a reference current source, with a level controlled by and identical to the bias current I_b. Diode-connected transistor Q_3, in parallel with grounded-emitter transistor Q_1 reduces temperature-induced variations and reduces the level of bias current required. The circuit output is buffered through Q_2.

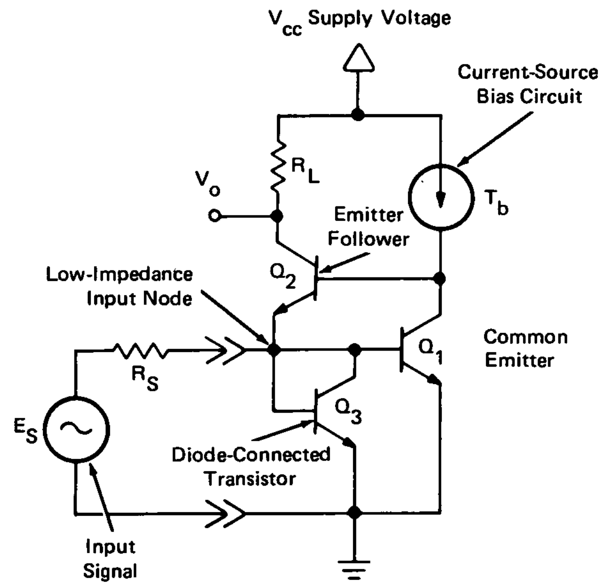


Figure 1. Transformer With Voltage Source

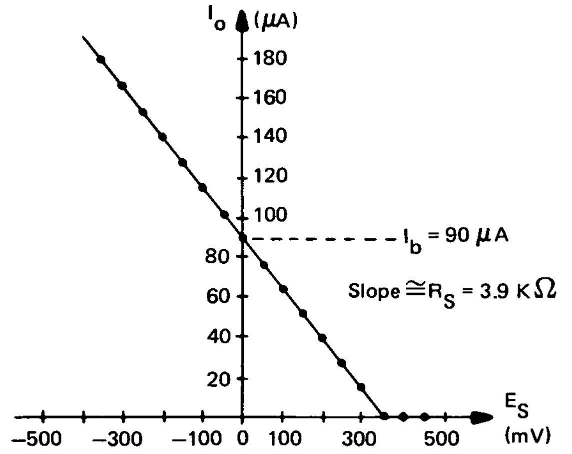


Figure 2. Transfer Characteristics With Voltage Source Drive

The linear transfer characteristic results from the low input impedance (less than 0.1 ohms) that is unaffected by the amplitude or polarity of the input signal (so long as it does not result in any current that exceeds the bias current).

Thus when the input signal comes from a voltage source, the input current is essentially E_S/R_S without the nonlinearities usually caused by varying and significant semiconductor-junction impedances. Figure 2 shows the voltage source transfer characteristic.

Source: D. L. Farnsworth of
Westinghouse Electric Company
under contract to
Marshall Space Flight Center
(MFS-22560)

Circle 11 on Reader Service Card.

OPERATION OF OLIGATOMIC MEMORY STACK

Small oligatomic memory stacks, with large capacities, reduce the number of modules normally required in a large computer system. This memory has a higher array density (13,900 bits/in.^{2}) than conventional core memories. The array is constructed in five layers: (1) glass substrate, (2) copper deposition, (3) silicon monoxide, (4) permalloy, and (5) another silicon monoxide layer. The glass substrate is coated with 40,000 Å of copper to form a ground plane. An insulating layer of SiO is deposited next, followed by a 100-Å layer of permalloy and another SiO. Photoetched overlays are attached on top with a spun-on layer of epoxy. A metal foil keeper is placed on top of the strip lines.

The stack assembly consists of four memory centerboards, two sense-digit selection boards, two sense-digit termination boards, two word-selection boards, and two word-termination boards. The second level word selector card is attached to the outside of the folded stack. Each centerboard has 49 locations for magnetic storage arrays. Two of the locations are populated with tested magnetic storage arrays that are directly addressed by the selection circuits, and two other locations are populated with untested magnetic storage arrays. These are for word-current monitoring and can be addressed only by physical wiring changes. There are 15 other locations with magnetic memory storage arrays immediately under the electronically addressable word and digit lines; these locations represent a uniformly distributed transmission line impedance. The remaining 30 locations are populated only with glass substrates.

Each centerboard contains approximately one-half the total length of the four digit-line and two word-line assemblies, which comprise the directly addressed lines. Each also has two indirectly accessed digit-line assemblies for word-current monitoring. A digit-line assembly consists of eight active lines, one dummy line, and one spare line that can be used as an active or dummy line depending upon the voltage connections made to the sense-digit selector circuit. The word-line assembly consists of two groups of 18 lines, of which 32 are active and four are spare lines. Counting only active lines, there are 64 sense-digit lines and 128 word lines directly accessible in the complete stack.

Development of the oligatomic memory stack is unique in that a continuous magnetic film is used as the storage media, digit-line and word-line overlays are longer and more dense than those previously produced, interconnections are not required between memory centerboards, and hybrid FET selection circuits are used in both the word and digit directions in a bit-organized selection scheme.

Source: R. L. Horst and M. J. Nordstrom
Sperry Rand Corporation
under contract to
Marshall Space Flight Center
(MFS-22330)

Circle 12 on Reader Service Card.

A VOLTAGE-TUNABLE THREE-TERMINAL GUNN DEVICE

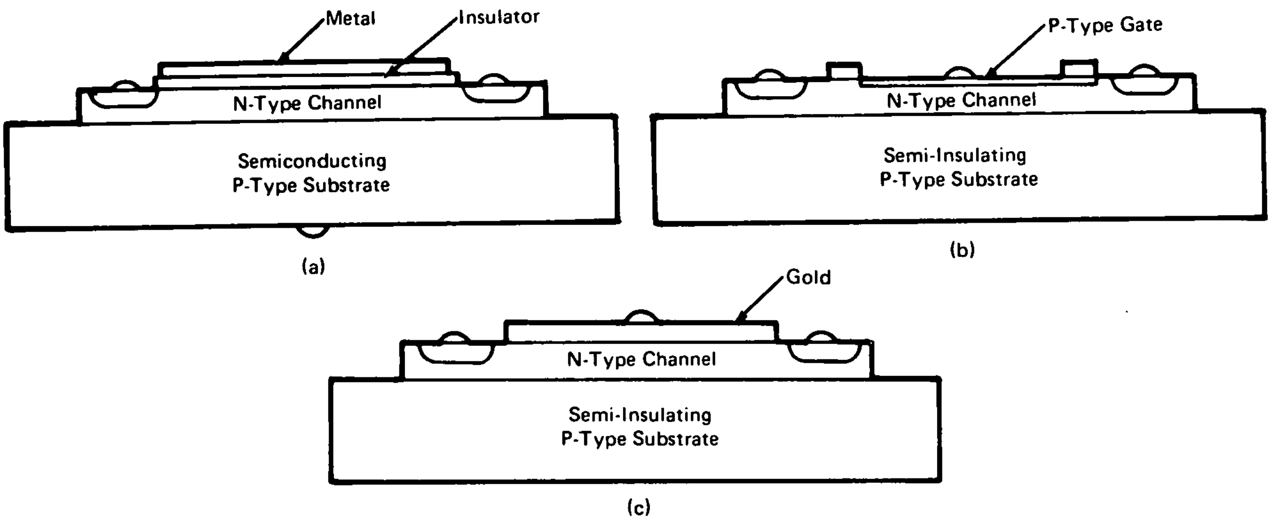


Figure 1.

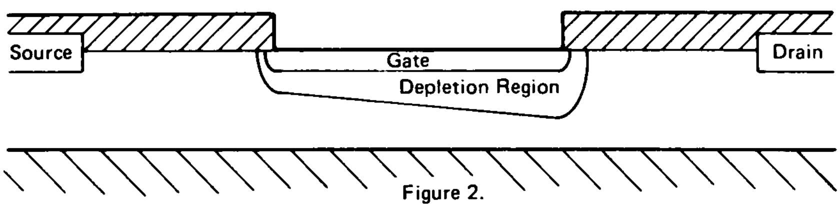


Figure 2.

Standard two-terminal Gunn oscillators require electrical or mechanical tuning of a resonant cavity to modulate the frequency of oscillation. The requirement for a resonant cavity adds to the size of the devices.

A voltage-tunable three-terminal Gunn device has been developed which does not require the bulky resonant cavity and which allows the oscillation frequency to be rapidly tuned with simple circuitry.

The newly developed Gunn oscillator, shown in Figure 2, is a three-terminal device which consists of a piece of gallium arsenide (GaAs) with the source, drain, and gate contacts. The oscillations occur because of domain formation and propagation through a thin epitaxial layer of GaAs, which has been deposited on a layer of semi-insulating GaAs. The Gunn domains propagate in a direction parallel to the substrate. The gate contact can be a metal-insulator-semiconductor sandwich, a reverse biased p-n junction, or a Schottky barrier junction, as shown in the Figure 1 sections (a), (b), and (c), respectively.

In one device that has been developed a Schottky barrier junction is used. The device operates at 460 MHz and has proved suitable as an oscillator in the 0.1 to 10 GHz range.

Source: R. J. Schwartz and J. J. Nahas of
Division of Sponsored Programs,
Purdue University
under contract to
NASA Headquarters
(HQN-10783)

Circle 13 on Reader Service Card.

HALL-EFFECT CHIPS WITHOUT OFFSET DRIFT

Hall-effect chips are usually characterized by considerable offset drift. This drift can be stabilized by placing a base diffusion over the entire Hall element, in a chip produced by the planar process. Thus, the Hall region of the chip is effectively isolated from the surface properties of the integrated circuits.

With a special mask, base diffusion can be placed over the entire chip, except where contacts must be made to the epitaxial layer. In addition to stabilizing offset, this diffusion results in a number of changed circuit parameters. These include increased Hall resistance, reduced Hall-element common-mode voltage, a broader offset distribution, and increased Hall-element sensitivity.

Source: M. L. Geske of
Honeywell Inc.
under contract to
Johnson Space Center
(MSC-14469)

Circle 14 on Reader Service Card.

MICROWAVE ANTENNAS MADE IN THE LAB

Microwave antennas can be made quickly and easily from copper-clad epoxy printed-circuit boards. This method was developed to allow horn-antenna feasibility testing when turnaround time by a model shop might be prohibitive.

A sheet of copper-clad epoxy board of the type used for printed circuits is laid out and cut on a small metal shear. The walls are butt joined, squared, and soldered together. The horn is then joined to a waveguide flange using a hotplate as a heat source.

Copper-clad board is rigid, solderable, lightweight, and easy to work. Modifications can be made with a 100-watt soldering iron, whereas a conventional metal structure requires complete redesigning. This method allows fast and inexpensive fabrication of breadboard antennas without preliminary models.

Source: August K. Parr and
Huo B. Yin of
IBM Corp.
under contract to
Goddard Space Flight Center
(GSC-11031)

No further documentation is available.

Patent Information

The following innovations, described in this Compilation, have been patented or are being considered for patent action as indicated below:

Stable Excitation Supply for Transducers (Page 1) MFS-21698

and

Spark Ultrasonic Transducer (Page 7) MFS-21233

and

Improved Gate Structure for MOS Transistors (Page 17) MFS-22616

These inventions are owned by NASA, and patent applications have been filed. Inquiries concerning license for their commercial development should be addressed to:

Patent Counsel
Marshall Space Flight Center
Code CC01
Marshall Space Flight Center, Alabama 35812

A Self-Supporting Strain Transducer (Page 6) LAR-11263

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Langley Research Center
Code 313
Hampton, Virginia 23665

Thermocouple Tape (Page 18) LEW-11072

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Lewis Research Center
Mail Stop 500-113
21000 Brookpark Road
Cleveland, Ohio 44135

Insulated ECG Electrodes (Page 20) MSC-14339

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to:

Patent Counsel
Johnson Space Center
Code AM
Houston, Texas 27058

Solid-State Current Transformer (Page 22) MFS-22560

and

Operation of Oligatomic Memory Stack (Page 23) MFS-22330

Inquiries concerning rights for the commercial use of these inventions should be addressed to:

Patent Counsel
Marshall Space Flight Center
Code CC01
Marshall Space Flight Center, Alabama 35812

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